

# Sequestration R&D

## Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	\$ Change	% Change
Sequestration R&D					
Greenhouse Gas Control.....	39,101	40,297	49,000	+8,703	+21.6%
Total, Sequestration R&D .....	39,101	40,297	49,000	+8,703	+21.6%

## Description

The mission of the Sequestration R&D program is to create public benefits by discovering and developing ways to economically separate and permanently store (sequester), and to offset, greenhouse gas emissions from the combustion of fossil fuels.

## Benefits

The Global Climate Change Initiative (GCCCI) has defined a metric goal of an 18 percent reduction in greenhouse gas intensity over the next ten years. The Sequestration Program will show substantial contributions toward meeting greenhouse gas intensity reduction goals of the GCCCI and provide a portfolio of “commercially ready” technologies to support the decision making process for future action (if required) in 2012, as mandated by GCCCI.

Technology developments will occur such that by the 2012 timeframe, carbon sequestration technologies will be available that result in less than 10 percent increase in cost of energy services for direct capture technologies and less than \$10/ton carbon sequestered for indirect capture technologies. Current capture and sequestration technology options result in at least a 30 percent increase for new plants and a 70 percent increase for retrofit plants. Using results from an FE/NETL analysis, the Sequestration Program has estimated the contribution that various options will make toward meeting the future greenhouse gas emissions reduction needs. Sequestration technologies have the potential to account for more than 30 MMtCE (million metric tons of carbon equivalents) greenhouse gas reduction in 2012 or about a 30 percent direct contribution to the President’s GCCCI goals. Sequestration technologies could potentially account for more than 90 MMtCE of greenhouse gas reduction in 2020 and up to 1025 MMtCE in 2050.

## Background

A successful research and development effort will allow the continued use of economical fossil fuels during the transition to a hydrogen economy.

About 90 percent of coal produced in the United States is used for electricity generation and over half of all electricity is produced by coal-fired power plants. Including electricity generated by oil and natural gas-fired power plants, approximately 70% of all electricity produced in the United States is generated

from fossil fuels. The continued use of fossil fuels to generate affordable electricity is critically important to the United States economy and the power generation industry needs to maintain a diversified fuel mix to ensure adequate energy supplies at a reasonable price. The continued use of fossil fuels has many environmental challenges, and sustained use could be severely limited unless satisfactory solutions can be found to overcome these environmental challenges, especially with regard to global climate change and the ability to substantially reduce carbon dioxide (CO<sub>2</sub>) emissions in the United States.

Since electric generation is expected to grow and fossil fuels will continue to be the dominant fuel source, there is growing recognition that the public/private collaboration must be part of the solution to curbing greenhouse gas emissions by capturing and permanently sequestering carbon dioxide. The President's recently announced climate change goal is to significantly reduce the greenhouse gas intensity of the United States economy over the next 10 years, while sustaining the economic growth needed to finance investment in new, clean energy technologies. The Carbon Sequestration Program directly supports these and several National Energy Policy (NEP) goals targeting the development of new technologies, market mechanisms, and international collaboration to reduce greenhouse gas intensity and greenhouse gas emissions. The development of carbon capture and sequestration technologies must play a key role if the United States is to set a path to slow the growth of greenhouse gas emissions, and -- if the emerging science justifies -- to stop and then reverse that growth.

The DOE is developing a portfolio of technologies and mitigation strategies designed to reduce the emissions of greenhouse gases using a two-prong approach: (1) Making energy systems more efficient, and; (2) Capture and sequestration of greenhouse gases. The first approach is being addressed by the core fossil energy coal, oil and gas programs and "Vision 21" that seek to almost double the current average efficiency of existing coal power plants by 2015. The second approach is being addressed by the Carbon Sequestration R&D Program. The Carbon Sequestration Program is developing a portfolio of technologies that hold great potential to reduce greenhouse gas emissions. The Program will focus primarily on the following area:

- Developing capture and separation technologies that dramatically lower the costs of reducing carbon dioxide emissions from fossil fuel processes.

The programmatic time line is to develop (to a state of commercial readiness) a portfolio of safe and cost effective greenhouse gas capture, storage and mitigation technologies by 2012, leading to substantial market penetration beyond 2012. Technology developments within the Sequestration Program are expected to significantly contribute to the President's goal of reducing greenhouse gas intensity by 18% by 2012 and would play a critical role should it be necessary to stabilize greenhouse gas emissions in the United States beyond 2012.

In addition to maintaining core R&D, the Sequestration Program will focus on the following programmatic thrusts in FY 2005:

- Pursue sequestration strategies that support zero. This activity enables sequestration opportunities that support the Global Climate Change, Clear Skies and FutureGen Initiatives.

- Strengthen U.S. and DOE leadership in carbon sequestration by pursuing global public/private R&D partnerships through the Carbon Sequestration Leadership Forum. In addition to seeking new opportunities, emphasis will be placed on strengthening and expanding existing cooperative efforts with Canada, Japan, Australia, Italy, Norway, and the European Union.
- Continue the development of the Regional Carbon Sequestration Partnerships. This activity focuses on promoting development of the infrastructure for wide-scale deployment of mitigation technologies and places more emphasis on bringing low-cost, value-added CO<sub>2</sub> capture and storage to the commercial implementation stage before 2012, while establishing the longer-term capability for addressing capture and sequestration from power generation. In FY 2005, the Partnerships will complete the following: (1) identify regional opportunities and benefits; (2) create a baseline and characterize a region by matching source and sink opportunities; (3) address safety, permitting, and public acceptance; and (4) provide technology validation for regional capture and storage opportunities. Planning will be completed and the solicitation for the Phase II Regional Carbon Sequestration Partnerships will also be released in FY 2005.
- Increase R&D focus on restoration of disturbed lands. Strengthen and expand R&D, including collaboration with the Department of Agriculture, Department of Interior and the Environmental Protection Agency to produce near-term benefits that directly contribute to the 2012 greenhouse gas intensity goal of the Global Climate Change Initiative.
- Accelerate Novel Sequestration Systems R&D to create expanded and new means of storing or reusing carbon and other greenhouse gas residuals that provide additional pathways to near zero emissions energy facilities of the future. Strong emphasis will be placed on technologies that offer permanent storage using chemical/biological pathways to inert, benign solids and useful products. The novel concepts projects awarded via collaboration with the National Academy of Sciences (NAS) will be reaching their midpoint in FY 2005 and future NAS collaboration opportunities will be assessed. These efforts will be coordinated with the DOE Office of Science, the IEA/GHG and other science organizations involved in the area.

### Detailed Justification

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
■ <b>Greenhouse Gas Control</b> .....	<b>31,277</b>	<b>33,050</b>	<b>41,580</b>
<p>In FY 2005, continue core R&amp;D program toward meeting the goals in the following areas: developing efficient, low-cost, advanced CO<sub>2</sub> separation and capture concepts; identifying issues associated with carbon sequestration in differing geologic formations, and reducing the cost, and environmental uncertainties (including storage stability, permanence, rates and characteristics of migration) of large-scale carbon sequestration through innovative Public-Private R&amp;D partnerships. Close collaboration with the carbon management science programs and activities in the Office of Science will be maintained for the purposes of applying promising basic science principles to novel concepts, thereby providing an integrated approach to advancing the science and technology of carbon sequestration. Regional partnerships to have (1) identified regional opportunities and</p>			

(dollars in thousands)

FY 2003	FY 2004	FY 2005
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benefits; (2) established a baseline and characterized a region by matching source and sink opportunities; (3) established preliminary monitoring and verification protocols; (4) identified appropriate regulatory framework for sequestration options; and (5) communicated with stakeholders through education and outreach programs. Launch technology validation phase of the regional carbon sequestration partnerships. Complete pilot tests on advanced capture technologies related to membrane and hydrate configurations. Complete field tests for non-CO<sub>2</sub> greenhouse gas mitigation related to fugitive methane emissions from coalmines. Complete field tests for geologic sequestration combined with enhanced coal bed methane recovery. *Participants include: NETL, LANL, Battelle, Praxair, Dakota Gasification, ARI, Nature Conservancy, Univ. of KY, Univ. of TX, VA Tech, MIT, Princeton University, Consol, IEA, TBD.*

In FY 2004, refocus core R&D program toward meeting the goals of the following areas: developing efficient, low-cost, advanced CO<sub>2</sub> separation and capture concepts; identifying issues associated with carbon sequestration in differing geologic formations, and reducing the cost, and environmental uncertainties (including storage stability, permanence, rates and characteristics of migration) of large-scale carbon sequestration through innovative Public-Private R&D partnerships. Close collaboration with the carbon management science programs and activities in the Office of Science will be maintained for the purposes of applying promising basic science principles to novel concepts, thereby providing an integrated approach to advancing the science and technology of carbon sequestration. *Participants include: NETL, LANL, Battelle, Praxair, Dakota Gasification, ARI, Nature Conservancy, Univ. of KY, Univ. of TX, VA Tech, MIT, Princeton University, Consol, IEA, TBD.*

FY 2003 funding continued development of models and predictive tools that will be required to assess the effectiveness of sequestration, advanced CO<sub>2</sub> capture approaches that are significantly less costly (capital and energy penalty costs), practical sequestration technologies specific to the types of geologic reservoirs found in the U.S., advanced fossil fuel conversion systems that produce a concentrated stream of CO<sub>2</sub> ready for sequestration, and measures to capture and control non-CO<sub>2</sub> greenhouse gases, and issue a solicitation for the Integrated Sequestration and Hydrogen Initiative. *Participants included: RTI, Media Processing Technology, LBNL, LLNL, ORNL, Texas Tech University, University of Kansas, TVA, MBARI, Alabama Geological Survey, Ohio University, PSU, University of Utah, OSU.*

■ <b>Focus Area for Carbon Sequestration Science....</b>	<b>7,425</b>	<b>6,844</b>	<b>6,930</b>
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In FY 2005, the most advanced CO<sub>2</sub> capture sorbent known, LiSiO<sub>4</sub>, will be tested in the flexible Modular CO<sub>2</sub> Capture Facility (MCCF) in the fuel gas mode. Several other sorbents will also be evaluated in the MCCF with particular emphasis on support to FutureGen or other large scale demonstrations. Measurement, monitoring & verification activities will continue to develop, evaluate, demonstrate and test new low cost surface and near surface methods for monitoring and verification of the integrity of geologically sequestered CO<sub>2</sub> at domestic sequestration sites, and possibly some foreign sites. NETL will continue to develop the theoretical basis for understanding field results from both the Burlington Resources and the CONSOL CO<sub>2</sub>-enhanced coalbed methane

(dollars in thousands)

FY 2003	FY 2004	FY 2005
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recovery projects. New insights and confirmation of previously developed hypotheses that are central to the continued development of coal seam sequestration will be developed. Key laboratory experiments will be conducted that confirm or deny previously developed insights. NETL's geological sequestration core flow laboratory (GSCFL) will obtain drilling core samples from the AEP/Battelle Mountaineer project in New Haven, WV, and begin evaluating the rock's permeability and porosity. The effects of CO<sub>2</sub> injection upon the host rock mineralogy and petrography will be investigated. *Participants include: NETL.*

In FY 2004, refocus activities toward the areas of capture, geologic and deep ocean CO<sub>2</sub> sequestration, establish the scientific and technical bases needed to cost-effectively capture and permanently sequester CO<sub>2</sub>. *Participants include: NETL*

FY 2003 funding continued development of wet scrubber systems to concentrate CO<sub>2</sub> from coal-fired power plants, facilities to test and evaluate advanced CO<sub>2</sub> capture systems applicable to both existing and advanced coal conversion processes and determine CO<sub>2</sub> flow characteristics in brine formations and coal seams, a state-of-the-art facility to mimic the formation of CO<sub>2</sub> hydrates in the deep ocean, and models to predict the extent of and verify sequestration of CO<sub>2</sub> in brine formations and in coals seams. *Participants included: NETL*

■ <b>Program Support</b> .....	<b>399</b>	<b>403</b>	<b>490</b>
Fund technical and program management support.			
<b>Total, Sequestration R&amp;D</b> .....	<b>39,101</b>	<b>40,297</b>	<b>49,000</b>

### Explanation of Funding Changes

FY 2005 vs. FY 2004 (\$000)
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#### Sequestration R&D

• Increased funding will be used to accelerate and broaden the characterization of additional regional geologic settings as potential sites for future sequestration, and accelerate the establishment of verification protocols and development of permitting issues to be addressed through the Carbon Sequestration Regional Partnerships .....	+8,703
<b>Total Funding Change, Sequestration R&amp;D</b> .....	<b>+8,703</b>